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"NASA CONNECT™: Space Suit Science in the Classroom"

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NASA CONNECT's™ program titled *Functions and Statistics: Dressed for Space* initially aired on Public Broadcasting Stations (PBS) nationwide on May 9, 2002. The program traces the evolution of past space suit technologies in the design of space suits for future flight. It serves as the stage to provide educators, parents, and students "space suit science" in the classroom.

WHAT IS NASA CONNECT™?

NASA CONNECT™ is an annual series of integrated mathematics, science, and instructional technology programs for students in grades 6-8. The program, produced by NASA Langley Research Center's Office of Education, has three components: (1) a 30-minute television broadcast, which can be viewed live or taped for later use; (2) a companion educator's guide, including an interactive hands-on activity; and (3) a web activity which provides educators an opportunity to integrate technology in a classroom setting. NASA CONNECT's™ web site is located at: http://connect.larc.nasa.gov and provides information for educators, parents, and students. The goals of NASA CONNECT™ are to:

- Present mathematics and science as processes requiring creativity, critical thinking, and problem-solving skills;
- Demonstrate workplace mathematics and science as a collaborative process;
- Raise awareness of careers requiring mathematics and science; and
- Overcome stereotyped beliefs by presenting women and minorities performing challenging engineering and science tasks.

Endorsed by the National Council of Teachers in Mathematics (NCTM), NASA Connect™ supports national mathematics, science, and technology standards. These programs use comparative reasoning as the thread to connect mathematics topics in each program. Additionally, the programs seek to establish a connection between the mathematics, science, and technology concepts taught in the classroom and those same concepts used everyday by NASA researchers.

NASA CONNECT™ is broadcasted on Public Broadcasting Stations (PBS), Cable Access Stations, NASA TV, and can be down-linked via satellite. Video copies of the program can be obtained from several sources, all of which are indicated on the web site. This series of programs has received several prestigious awards, including the National Academy of Television Arts and Sciences Regional Emmys for the San Francisco/Northern California Chapter, the Rocky Mountain Southwest Chapter, and the Washington, D.C. Chapter for children's programming.

During the 30-minute broadcast or taped video, there are cue card questions posed by students. Norbert, NASA CONNECT's™ animated co-host, poses questions directly related to the program's topic and encourages students to think about the concepts being presented. When viewing a videotaped version of NASA CONNECT™, educators have the option to use Norbert's Pause, which gives them an opportunity to have students reflect and record their answers on the cue cards that are provided in the educator's guide. Norbert appears with a remote to indicate an appropriate time to pause the videotape and discuss the answers to the questions. The following questions are asked during *Functions and Statistics: Dressed for Space:*

1. What is an EMU?
2. Why is sizing a space suit critical to astronauts?
3. Why can't space suits be tailored for each astronaut?
4. What will future space suits be used for?
5. How do you evaluate advanced space suits?
6. Analyzing the data, which suit has the best elbow performance?

As in all NASA CONNECT™ programs, hands-on activities that support the topic are teacher-created. In the program *Functions and Statistics: Dressed for Space,* students investigate how different colors, reflective surfaces, and different materials are affected by radiant heat absorption and heat radiation. They plot, analyze, and summarize data to determine the validity of student predictions. Essentially, students are placed in groups and are given materials as noted in the educator guide, including student worksheets to record requested data.

What makes this series of standards-based programs so unique? Imagine having a NASA engineer, scientist and/or researcher communicating their knowledge to increase scientific literacy to students and educators across the country in both formal and informal settings. Through demonstrating processes of creativity, critical thinking, and problem solving, NASA CONNECT™ is an example of how to take mathematics, science, and technology to the classroom in an exciting and technologically advanced format.

In the program *Functions and Statistics: Dressed for Space*, students learn about the challenges facing the human body in a space environment. The objectives are for students to learn how the Mercury, Gemini, and Apollo space suits were developed and why sizing a space suit is critical for astronauts working in space. They are also introduced to three advanced space suit prototypes: the H-Suit, I-Suit, and the D-Suit. Students observe NASA engineers and researchers using math, science, and technology to create the next generation of space suits for use outside the safe environment of the earth. Students can also conduct hands-on activities and web activities supporting the program topic, making a substantial connection between NASA research and the mathematics, science, and technology they learn in the classroom.

Filmed at the Johnson Space Center in Houston, Texas, NASA CONNECT's™ hosts Jennifer Pulley and Dan Geroe talk with NASA engineers and researchers who create the next generation of space suits. Students receive a quick history lesson on spacesuit development, beginning with NASA's Mercury Program. Spacesuits during the Mercury Program kept the designs of the early-pressurized flight suits, but added layers of aluminized Mylar to give it strength and temperature resistance. Astronauts carried an external fan to keep their suits cool. The suit was only pressurized in the event the cabin pressure failed. During the Gemini phase of the space program, astronauts found it difficult to move in the Mercury space suit when it was pressurized. Because the space suit was not designed for space walking, changes were made. Gemini astronauts also learned that cooling the spacesuit with air did not work well. Astronauts were overheated and exhausted from space walks and their helmets were fogged up on the inside from excessive moisture.

When discussing space suit design, one of the first things that must be understood is how atmospheric pressure, or rather the lack of atmospheric pressure, is related to having human beings explore and work in space. Atmospheric pressure is the amount of force exerted over a surface area caused by the weight of air molecules above it. As elevation increases, fewer air molecules are present making atmospheric pressure decrease proportional to height increase. For example, at 5486.4 meters above sea level, air pressure is only half as dense as it is on the ground. At 19202.4 meters above sea level, air is so thin that humans must wear space suits that supply oxygen for breathing and air pressure. To explore and work in space, human beings must take their environment with them because there is no atmospheric pressure and no oxygen to sustain life. Only in the spacecraft can the atmosphere be controlled.

In the late 1960s astronauts walked on the moon. Space suit designers came up with some creative solutions based on information they learned and collected during the Gemini program. A single spacesuit was developed that had add-ons for moonwalking. The Apollo suit was no longer cooled with air. Instead of using air, a nylon undergarment mesh cooled the astronaut's body with water. A good analogy for this design is when cars are cooled by water in its radiator. The Apollo suit also had additional layers of fabric to provide better pressurization and additional heat protection. For moon walking purposes, the spacesuit was supplemented with additional gear, including gloves with rubber fingertips and a portable life support backpack that contained oxygen, carbon dioxide removal equipment and cooling water. The spacesuit and backpack on earth weight 82 kg, but only weight 14 kg on the moon due to the moon's lower gravity.

NASA spacesuit designers use the term "extravehicular mobility unit"(EMU) to describe the current spacesuit. The EMU combines soft and hard components that provide support, mobility, and comfort. The suit has 13 layers, including an inner cooling garment, a pressure garment, a thermal micrometeriod garment, and an outer cover. All layers are sewn and cemented together to form the suit. The space suit assembly includes the life support system, the display and control module, and several other crew items designed for space walks and emergency life support. The EMU accommodates a variety of interchangeable systems that interconnect easily and securely in a single-handed operation for either normal or emergency use. It provides the astronaut with oxygen for breathing and maintains a pressure around the body to keep the body fluids in a liquid state. At an altitude of 19,000 m (19km), the air pressure is no longer sufficient to keep body fluids from boiling. Furthermore, the sudden absence of external pressure that balances the internal pressure of body fluids and gases would rupture fragile tissues such as eardrums and capillaries. The net effect on the body would be swelling, tissue damage, and a deprivation of oxygen to the brain that would result in unconsciousness in less than 15 seconds. Although the space suits were individually tailored for each astronaut, the EMU has component pieces of varying sizes that can be put together to fit any astronaut. The cost of an EMU is approximately 12 million dollars.

Currently, NASA has over 100 astronauts and many of them are trained for space walks. At any one time, NASA can piece together approximately 14 suits. Sizing of spacesuits is done using mathematics, taking measurements of different body parts such as the head circumference, height, chest diameter, hip and waist, inseam, knee position, elbow position and arm length. The measurement data is processed and compared against available parts in the inventory. Then a fairly accurate estimate is made of what parts are needed to fit an individual astronaut, from the base of the hard upper torso or fiberglass shirt to the boots, legs, arms, and helmet. Aluminum sizing rings are added in key place to adjust lengths. Smaller adjustments can be made through tweaking some other parts. Technicians assemble a suit for those parts. Just like trying on clothes in a store, the astronaut comes in for a fitting of his/her suit. The only part of the suit where custom parts may be manufactured for a specific person is the gloves.

Engineers use math to size spacesuits using statistical averages. For instance, measuring all males on Earth would take a long time to complete. However, by taking a sample of males to arrive at a set of numbers that will represent the actual total of males on the planet is what is done. Typical males range in height from approximately 170 cm to 190 cm. A similar height range is used for females since it is very expensive to design, manufacture, and test spacesuit components.

One of the most challenging aspects of fitting spacesuits to an individual astronaut is actually taking measurements of the human body. Several technicians take the same measurement to see if the results match. Accuracy is important in sizing a spacesuit.

Space suit engineers today are evaluating the performance of advanced space suit configurations. The suits shuttle astronauts use for space walking are good for repairing an occasional satellite, and they will be adequate for assembling the International Space Station, but for mountaineering or searching for water on Mars, the current suits are essentially of no use. NASA is developing early prototypes of what, in decades to come, will be a versatile outfit for exploring the nearby planets. Three configurations being tested are: the H-Suit, the I-Suit, and the D-Suit.

The H-Suit represents a hybrid space suit configuration since it is made up of hard and soft components. The hard components include the upper and lower torso, and the soft components include the fabric elbows and knees. The H-Suit uses rotating bearings in its multi-axis mobility joint system, which is a system that allows a person to move through most of the natural ranges of motion. Rotating bearings placed at main body joints allows for that mobility. Additionally, the H-Suit has bearings at the shoulder, upper arm, waist, upper hip, mid-hip, upper leg, and knee joints. It is called the H-Suit because the suit is entered through a hatch on the backside of the hard upper torso. Modified EMU boots used in the current design are part of the H-Suit. The suit's total weight is approximately 59 kg.

The second space suit configuration being tested is the I-Suit. The I-Suit is primarily a soft suit, yet it incorporates a limited number of bearings at the shoulder, upper arm, waist, upper and mid hip, upper leg, and ankle joints. This flexibility gives the astronaut the ability to rotate their shoulders, arms, and legs. This all-fabric design is light, packs smaller, and is much less expensive to make and tailor to individual astronauts. This space suit weights 29 kg, making it much lighter than the H-Suit.

Another space suit configuration, the D-Suit, is a lightweight "soft" suit that weighs about 10.4 kg and has only one bearing in the center of the torso. That joint is used for getting in and out of the suit, and it allows the astronaut's upper body to rotate. While the soft suit is much lighter than the I-Suit with its many bearings, it affords the astronaut less movement. It remains to be seen exactly what the "next generation" space suit will look like; however, it is likely the final design will incorporate the best of what is learned from these prototypes.

References

Barton, Byrom: *I Want to Be an Astronaut,* Harpercollins Juvenile Books, 1992.

Heinlein, Robert A.: *Have Spacesuit, Will Travel,* Ballentine Books, 1995.

Kozloski, Lillian D.: *U.S. Space Gear: Outfittng the American Astronaut,* Smithsonian Institute Press, 2000.

Mullane, Mike R.: *Do Your Ears Pop in Space? And 500 Other Surprising Questions abut Space Travel,* John Wiley and Sons, 1987.

Nye, Jody Lynn: *Don't Forget Your Spacesuit, Dear* Baen Books, 1996.

Thompson, Kim; Paskiet Mark: *I'd Like to be an Astronaut; Learning About Gravity, Space Travel and Famous Astronauts,* Twin Sisters Productions, 1996.

Zurbin, Robert. *Entering Space: Creating a Spacefaring Civilization,* J P. Tarcher, 2000.